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| <p align="center">National Park Service Plant Materials 1991 Annual Report Grand Canyon National Park, Arizona</p> |
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I. Background

This Agreement with the Grand Canyon National Park, Arizona, was executed July 1990 and covers the years 1990 through 1994. The Parks Resources Management Division appointed a liaison person (COTR, Contracting Officer Technical Representative). SCS in Arizona provided technical assistance via a staff person. This Agreement provides for the collection, propagation, and increase of grasses, forbs, shrubs and trees. In 1991, there were five collection trips which were conducted during the months of June, July, September and November.

The Park will use the plant materials for nine acres of roadside revegetation on East Rim Drive; one acre at Maswik Parking lot; five acres of cut slope and roadsides on Center Road; 0.5 acres at Yavapai Parking Area; nine acres of new road location at the East Rim Entrance; with additional, as yet unplanned, revegetation to be done at Village Loop Road, South Entrance Road, Visitor Center Parking Lot, and a new road from residential area to business center. This year, the NPS increased the contract amounts of all grasses, shrubs, forbs and Utah juniper to meet expanded future planting needs.

New technology, so far involved, includes attempting several different methods of propagating or increasing species for which there are little published procedures available.

II. Accessions Involved

| Common Name | Scientific Name | Plant Symbol | Accession Number | Vegetation Association |
|--------------------------------|-----------------------------------|--------------|------------------|------------------------|
| Indian ricegrass | <i>Orzyopsis hymenoides</i> | OrHy | 9062857 | 122.3233 |
| Squirreltail | <i>Sutania hysterix</i> | SiHy | 9062858 | 122.3233 |
| Needle and thread | <i>Stipa comata</i> | StCo | 9062859 | 122.3233 |
| Western wheatgrass | <i>Agropyron smithii</i> | AgSm | 9062860 | 122.3233 |
| Muttongrass | <i>Poa fendleriana</i> | PoFe | 9062861 | 122.3233 |
| Penstemon (blue) | <i>Penstemon</i> spp. | Pe spp. | 9062862 | 122.3233 |
| Penstemon (red) | <i>Penstemon</i> spp. | Pe spp. | 9062895 | 122.3233 |
| Lupine | <i>Lupinus</i> spp. | Lu spp. | 9062863 | 122.3233 |
| Cliffrose | <i>Cowania mexicana</i> | CoMe | 9062864 | 122.3233 |
| Apacheplume | <i>Fallugia paradoxa</i> | FaPa | 9062865 | 122.3233 |
| Fernbush | <i>Chamaebatiaria millifolium</i> | ChMi | 9062866 | 122.3233 |
| Curl leaf mountain mahogany | <i>Cercocarpus ledifolius</i> | CeLe | 9062867 | 122.3233 |

| Common Name | Scientific Name | Plant Symbol | Accession Number | Vegetative Population |
|-------------------|--------------------------------|--------------|------------------|-----------------------|
| Elderberry | <i>Sambucus</i> spp. | Sa spp. | 9066047 | 122.3233 |
| Utah serviceberry | <i>Amelanchier utahensis</i> | AmUt | 9062869 | 122.3233 |
| Wolfberry | <i>Lycium</i> spp. | Ly spp. | 9062870 | 122.3233 |
| Gambel oak | <i>Quercus gambelii</i> | QuGa | 9062872 | 122.3233 |
| Fourwing saltbush | <i>Atriplex canescens</i> | AtCa | 9062873 | 122.4149 |
| Century plant | <i>Agave utahensis</i> | AgUe | 9062874 | 122.4149 |
| Blue grama | <i>Bouteloua gracilis</i> | BoGr | 9062875 | 122.4149 |
| Rabbitbrush | <i>Chrysothamnus nauseosus</i> | ChNa | 9062877 | 122.4149 |
| Cliffrose | <i>Cowania mexicana</i> | CoMe | 9062876 | 122.4149 |
| Utah juniper | <i>Juniperus osteosperma</i> | JuOs | 9066055 | 122.3233 |
| Big sagebrush | <i>Atriplex tridentata</i> | ArTi | 9066056 | 122.3233 |
| Currant | <i>Ribes</i> spp. | Ri spp. | 9066057 | 122.3233 |
| Datil yucca | <i>Yucca baccata</i> | YuBa | 9066058 | 122.3233 |
| Desert barberry | <i>Berberis fremonti</i> | BeFe | 9066059 | 122.3233 |
| Gambel oak | <i>Quercus gambelii</i> | QuGa | 9066060 | 122.4149 |
| Utah juniper | <i>Juniperus osteosperma</i> | JuOs | 9066061 | 122.4149 |

III. Collection Information

Collections were made at thirteen locations scattered over a distance of 35 miles along the south rim of Grand Canyon. With the concurrence of the Park's COTR, the collections have been combined into two populations. The populations are based upon Vegetation Associations described in Technical Report No. 9; "Vegetation of Grand Canyon National Park", 1982. While the NPS had originally advised us to consider all collections along the south rim as one population, we decided to break out one additional population because of differences in site characteristics.

Vegetation Association 122.3233 - *Pinus ponderosa*, *Pinus edulis*, *Quercus gambelii*, *Juniperus osteosperma*. Elevation range 6,000 to 7,500 feet. Level to gently sloping. Soils are moderately shallow, with silty loam textures, derived from Kaibab limestone or volcanic outcrops.

The following species were collected within Vegetation Association 122.3233 on the indicated dates:

| Common Name | Field Collections (uncleaned) | Dates of Collection | | | |
|--------------------|-------------------------------|---------------------|------|-----------|----------|
| | | June | July | September | November |
| Indian ricegrass | 881 gms | X | X | | |
| Squirreltail | 990 gms | X | X | X | |
| Needle and thread | 125 gms | | X | | |
| Western wheatgrass | 209 kgms | | | X | |
| Muttongrass | 169 gms | | X | | |
| Lupine | 5.6 gms | | | X | |
| Apacheplume | 2 gms | | X | | |
| Curl leaf | | | | | |
| mountain mahogany | 86 gms | | X | | |
| Gambel oak | 1400 seeds | | | | X |
| Utah juniper | 2500 seeds | | | X | X |
| Big sagebrush | 920 plts | | X | X | |
| Currant | 1.4 gms | | | X | |
| Elder | 3.6 gms | | | X | |
| Cliffrose | 4 gms | | | X | |
| Blue penstemon | 6.2 gms | | | X | |
| Red Penstemon | 2.2 gms | | | | |
| Pinyon pine | 6500 seeds | | | | X |

Vegetation Association 122.4149 - *Pinus edulis*, *Juniperus osteosperma*, *Poa pratensis*. Elevation range is 6,400 to 7,000 feet. Level terrain with moderately deep soils, often gravelly with sandy loam texture, derived from Kaibab limestone.

The following species were collected within Vegetation Association 122.4149, on the indicated dates:

| Common Name | Field Collections (uncleaned) | Dates of Collection | | | |
|--------------|-------------------------------|---------------------|------|-----------|----------|
| | | June | July | September | November |
| Blue grama | 168 gms | | | | X |
| Utah juniper | 1300 seeds | | | | X |

IV. Seed Condition Information

| Species | Date Cleaned | Cleaned Weight in Grams | Seed Quality |
|--------------------|--------------|-------------------------|--------------|
| Indian ricegrass | August | 236 gm | Good |
| Squirreltail | September | 270 gms | Good |
| Needle and thread | September | 90 gms | Good |
| Western wheatgrass | September | 662 gms | Good |
| Muttongrass | September | 95 gms | Good |
| Lupine | September | 2 gms | Good |
| Apacheplume | September | .5 gms | Poor |
| Curl leaf | | | |
| mountain mahogany | August | 56 gms | Good |
| Blue grama | December | 130 gms | Good |
| Utah juniper | December | 5-600 seed | Poor |
| Currant | September | .5 gms | Good |
| Elder | September | 16 gms | Good |
| Cliffrose | September | 2 gms | Good |
| Blue penstemon | September | 4 gms | Good |
| Red penstemon | September | 1.5 gms | Good |

No determinations were made for purity or germination percentages.

Grand Canyon precipitation was below normal.

V. Seed Production Establishment in 1991

| Species | Contract Amounts | | Estimated Production Per Acre | Acres Required for Production | Acres in Production | Stand Rating | Establishment Method |
|----------------|------------------|----|-------------------------------|-------------------------------|---------------------|--------------|----------------------|
| | 92 | 93 | | lbs | | | |
| Blue grama | 18 | 9 | 50 | 0.50 | 0.25 | Good | Plants |
| Bottlebrush | | | | | | | |
| squirreltail | 46 | 20 | 75 | 0.75 | 0.75 | Good | Plants |
| Needle | | | | | | | |
| and thread | 90 | 30 | * | | | | |
| Muttongrass | 24 | 20 | * | | | | |
| Western | | | | | | | |
| wheatgrass | 150 | 90 | 120 | 1.50 | 1.20 | Good | Plants |
| Red penstemon | 36 | 18 | 180 | 0.30 | ** | N/A | Plants |
| Blue penstemon | 12 | 6 | 120 | 0.30 | *** | N/A | Plants |
| Lupine | 0 | 0 | - | - | 0.05 | Good | Plants |

*Being grown at Meeker

**3900 transplants to be lined out in 1992

***3350 transplants to be lined out in 1992

VI. Seed Production

There was no seed produced in 1991.

VII. Transplant Production

| Species | Contract | | Number in Production | | | | | Specialized |
|--------------------|----------|-----|----------------------|------------|------------|---------|----------|-------------|
| | Amounts | | Rootrainer | Rootrainer | Rootrainer | Deepots | Treepots | |
| | 92 | 93 | 90 | 350 | 750 | | | Treatments |
| Fourwing saltbush | 900 | 400 | | 280 | 243 | | 100 | 1 |
| Big sagebrush | 900 | 400 | | | | 1500 | 100 | 2 |
| Rubber rabbitbrush | 900 | 400 | | 575 | 324 | | 200 | 3 |
| Fernbush | 600 | 400 | | 200 | 510 | | 200 | 4 |
| Cliffrose | 600 | 300 | | 500 | 400 | | 75 | 5 |
| Apacheplume | 600 | 300 | | 250 | 450 | | 200 | 6 |
| Gambel oak | 600 | 300 | | 1500 | | | | 7 |
| Yucca | 650 | 0 | | | | | 36 | 8 |
| Century plant | 500 | 0 | 275 | 300 | | | | 9 |
| Curl leaf mahogany | 0 | 0 | | 30 | | | | 10 |
| Utah serviceberry | 0 | 0 | | 480 | | | | 11 |
| Wolfberry | 0 | 0 | | 200 | | | | 12 |
| Currant | 0 | 0 | | | | | 50 | 13 |
| Desert barberry | 0 | 0 | | 56 | | | | 14 |

All plants were started from seed.

See 1990 report for specialized treatments of each species.

VIII. Specialized Treatments in 1991

1. Fourwing saltbush seed was sown into Roottray seedling flats and cold stratified for four weeks. Germination was good. Seedlings were initially transplanted into Rootrainer 65 containers (1" x 1" x 4 1/4"), using Metro Mix 360 growing medium. They were fertilized one to two times per week with Peter's Professional Fertilizer (20-10-20) applied by using 1:100 liquid fertilizer proportioner and a solution of one cup Peters in one gallon of water.

Fourwing saltbush seedlings were later transplanted from Roottrainer 65 containers to Roottrainer 350 (1 1/2" x 2" x 8" deep), Roottrainer 750 (2" x 2 1/2" x 10" deep) and one gallon treepots (4" x 4" x 14" deep), as indicated in Table VII. Metro Mix 360 growing medium was used in the Roottrainer 350 and 750 containers and a combination of Metro Mix 360 and compost (1:1) was used in the one gallon treepots.

2. One hundred big sagebrush seedlings were transplanted to one gallon treepots using Metro Mix 360 growing medium. The other seedlings remained in deepots (2 1/2" diameter x 10" deep). Two more collections of wild seedlings were made and they were planted into deepots using Metro Mix 360 growing medium.
3. Rubber rabbitbrush seed was sown into Roottray seedling flats and received no pretreatment. Germination was good. Seedlings were initially transplanted into Roottrainer 65 containers using Metro Mix 360 growing medium. They received the same fertilization as the fourwing saltbush seedlings.

Rubber rabbitbrush seedlings were later transplanted from Roottrainer 65 to Roottrainer 350, Roottrainer 750 and one gallon treepots, as indicated in Table VII. Metro Mix 360 growing medium was used in the Roottrainer 350 and 750 containers and a combination of Metro Mix 360 and compost (1:1) was used in the one gallon treepots.

4. Fernbush seedlings were transplanted from Roottrainer 90 containers to Roottrainer 350, Roottrainer 750 and one gallon treepots, as indicated in Table VII. Metro Mix 360 growing medium was used in all containers.
5. Cliffrose seedlings were transplanted from Roottrainer 90 containers to Roottrainer 350, Roottrainer 750 and one gallon treepots, as indicated in Table VIII. Metro Mix 360 growing medium was used in the roottrainer 370 and 750 containers and a combination of Metro Mix 360 and compost (1:1) was used in the one gallon treepots.
6. Apacheplume seedlings were transplanted from Roottrainer 170 (1 1/2" x 1 1/2" x 5" deep) to Roottrainer 350, Roottrainer 750 and one gallon treepots, as indicated in Table VII. Metro Mix 360 growing medium was used in the Roottrainer 350 and 750 containers and a sewage sludge compost medium was used in the one gallon treepots.
7. Gambel oak seedlings remained in Roottrainer 350 containers.
8. Datil yucca seedlings were transplanted from Roottrainer 350 containers to one gallon treepots using Metro Mix 360 growing medium.

9. Century plant seedlings were transplanted from Rootrainer 90 to Rootrainer 350 containers using Metro Mix 360 growing medium. Additional century plant seed was germinated and transplanted into Rootrainer 90 containers, using Metro Mix 360. These seedlings will be kept in the greenhouse until they are large enough to transplant.
10. Curl leaf mountain mahogany seedlings were transplanted from Rootrainer 90 to Rootrainer 350 containers using Metro Mix 360 growing.
11. Utah serviceberry seedlings were transplanted from Rootrainer 90 to Rootrainer 350 containers using Metro Mix 360 growing medium.
12. Wolfberry seedlings were transplanted from Rootrainer 65 to Rootrainer 350 containers using Metro Mix growing medium.
13. Currant seedlings were transplanted from Rootrainer 90 containers to one gallon treepots using Metro Mix 360 growing medium.
14. Desert barberry seedlings were transplanted from Rootrainer 90 to Rootrainer 350 containers using Metro Mix 360 growing medium.

All plants were moved out to the lathhouse and will be held there until needed. While in the lathhouse, Peters Professional Fertilizer (20-10-20) was applied once using a 1:100 liquid fertilizer proportioner and a solution of three cups Peters in one gallon of water. A fungicide drench was also applied once in October, using a 1:100 proportioner and a solution of three cups Banrot 406 wettable powder in one gallon of water.

IX. Observations

Metro Mix 360 growing medium is very high in organic matter, resulting in high water holding capacity and slow drainage. A few of the species did not grow well under these conditions and had poor root development and some root rot. The species most sensitive to this condition are cliffrose, apacheplume, wolfberry and fernbush. A fungicide drench was applied to help alleviate these symptoms. However, we hope to avoid these problems in the future by using a coarser, better draining media.

We have observed that evergreen desert shrubs do not overwinter in containers as well as deciduous plants. Therefore, some winter kill in these species should be expected.

Unlike the other species, fernbush seedlings had poor survival after the initial "bareroot" type transplanting from Rootray seedling flats to Rootrainers. To overcome this problem, the seed was directly sown into the

Rootrainer 90 containers and thinned to one plant per cell. There were no problems in the following transplantings from Rootrainer 90 containers to larger containers.

Two attempts have been made at collecting and germinating Utah juniper seed without success. Inspection of the seed revealed that the seed was unfilled or immature. We have since researched the topic and found that the seed of this and some other species of native juniper, are notorious for having poor seed fill and are therefore difficult to propagate. We suggest that in addition to collecting seed, we take cuttings this winter and experiment with vegetative propagation. If that is unsuccessful, we can transplant wild seedlings to containers.